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Information system for assessing maturity level of an organization

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Introduction. The paper considers problems of creating information support for solving the task of assessing the maturity level of an organization. It is proposed to use intelligent information systems, i.e. expert systems. Substantive aspects of various stages of creating such systems are briefly described; the expert system architecture, which is based on using a fuzzy expert knowledge base, is given. The work objective was to create new software to solve the problem of assessing the maturity level of an organization.

Materials and Methods. Previously performed modeling of the subject domain under consideration allowed us to create a knowledge base in the form of production memory, which is the basis of the fuzzy inference mechanism. The software is written in PHP and is suitable for embedding in complex web applications. The software system is a web application written primarily in PHP and JavaScript. The software works in all modern web browsers, which accelerates significantly the implementation and deployment based on both the parent-enterprise and its subsidiaries.

Results. New software has been created to automate the processing of questionnaires during the organization's self-assessment based on key indicators, as well as considering 6 main groups of the quality management system indicators. Application of the program will significantly speed up the process of input and processing of expert information required for self-assessment. The program provides organizations to get an adequate idea of the opportunities and prospects for improving the organization's quality management system. Some fragments of the software system interface are given.

Discussion and Conclusions. The proposed software can be used to determine the level of maturity of an organization. The application of Web-technologies improves usability, reduces software support costs. The software can be deployed in the existing network infrastructure of the customer; and the customer can use all the functionality through connecting to a remote server. The software is optimized for various screen resolutions, which allows you to use it not only at the central office, but also when analyzing the quality management system of corporate customers. The traffic generated by the web application is optimized for working with mobile devices with a low-speed Internet connection. Application of the program will significantly reduce the time for users to enter and process expert information required for the problem solving and to eliminate duplication of information.

Keywords: information support, quality management system, level of maturity of an organization, self-assessment, expert systems.

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Introduction. Achieving sustained success is an urgent task for every business entity (enterprise, organization, firm, etc.). The sustained success of the organization running presupposes providing its high operating rate and optimal balance. In this case, the interests and needs of all parties related to the enterprise should be taken into account. For example, product quality should meet customer requirements; terms, volumes of supplies and purchases — the contractual obligations with partners and suppliers; financial performance —the expectations of management and owners. The modern rapidly changing economy requires a prompt response to external influences; therefore this aspect of the analysis of activities is of particular importance. The qualitative and quantitative characteristics that affect the functioning of the organization should be balanced, which is the main criterion for providing success. Self-assessment is one of the primary tools for analyzing the functioning of an organization; it provides continuous monitoring of the state of an organization, which is a fundamental way to maintain competitiveness.

In our country, the problem of self-assessment of the organization's activities is studied in sufficient scale for certain areas of practical experience. These are the works by Eh. A. Belokorovin, V. I. Galeev, E. A. Gorbashko, T. Yu. Dvoruk, B. C. Dubinin, T. Kalita, A. I. Kochetov, D. V. Maslov, Yu. I. Mkhitaryan, I. G. Okrepilova, T. A. Salimova, M. Z. Svitkin and others[1]. Various methods and approaches to self-assessment and assessment of the organization's performance in certain industries, as well as its further improvement and increasing competitiveness were considered in foreign publications [1–5].

The urgency of the problem, covering various aspects of the organization self-assessment process based on an approach using a quality management system (QMS), is validated, first of all, by its applied significance, since the organization's maturity levels are closely related to the problem of quality assurance and control[2]. For an adequate assessment of the QMS operation, subject field professionals, experts, are used. However, a major problem accompanying the solution to the problem is the necessity of taking into account a variety of expert information, including qualitative, the subjectivity of expert assessments, as well as an insufficient number of experts. In this regard, to solve these problems, it is advisable to use intelligent decision support systems.

The application of new technology (expert systems) will provide finding the optimal solution to the problem of self-assessment of the organization. Further general automation of the enterprise will be provided through the development of a system that includes a set of hybrid expert systems and, as a consequence, will bring about an increase in the efficiency of the enterprise.

The experts' use of knowledge (heuristics) obtained during the entire period of professional activity in a specialized subject field is a specific feature of expert systems (ES).

When qualitative and quantitative assessments are ambiguous, ES are used for decision-making both in technical problems of decision-making [6] and in management, production, logistics processes [7–11], service quality assessment[3], knowledge quality assessment[4], and other humanitarian fields. To determine the level of maturity of the organization, the authors proposed a general scheme[5]. The scheme assumes using expert assessments and developing an ES [12], whose decision making is based on fuzzy inference [13–15].

The work objective is to create a computer system that automates the self-assessment process, which will significantly increase the efficiency of the decision-maker (DM) in the process of solving this problem and, in particular, in determining the level of maturity of the organization. The use of this computer system provides the

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[5]Dimitrova LA. General scheme for assessing the level of maturity of an organization based on fuzzy expert knowledge. In: Proc. Sci.-Method. Conf. on Innovative technologies in science and education "ITNO-2016". Rostov-on-Don, 2016. P. 357–360. (In Russ.)

application of the heuristics of experts, expansion of the boundaries of the solutions and recommendations being developed, and increasing their significance.

Materials and Methods. The practice of developing ES shows that the evolutionary creation method has become dominant in the field of ES. Consider the substantive aspects of the stages and features of the design of the software package (Fig. 1). The essential features of the identification stage include the determination the objectives and tasks of creating an ES; the selection of the type and breadth of the problem statement; defining the assignment of the required resources (time and "computer capacity") and participants in the development process.

Let us list the types of problems that can be solved using ES:

— systematization of the accumulated experience of self-assessment when analyzing the QMS operation;

— using the features of experience in solving problems of expert assessment;

— prompt solution to the problem of assessing the level of maturity of the organization;

— registration of specific moments in the audit of the organization and the dissemination of methods aimed at eliminating their negative impact.

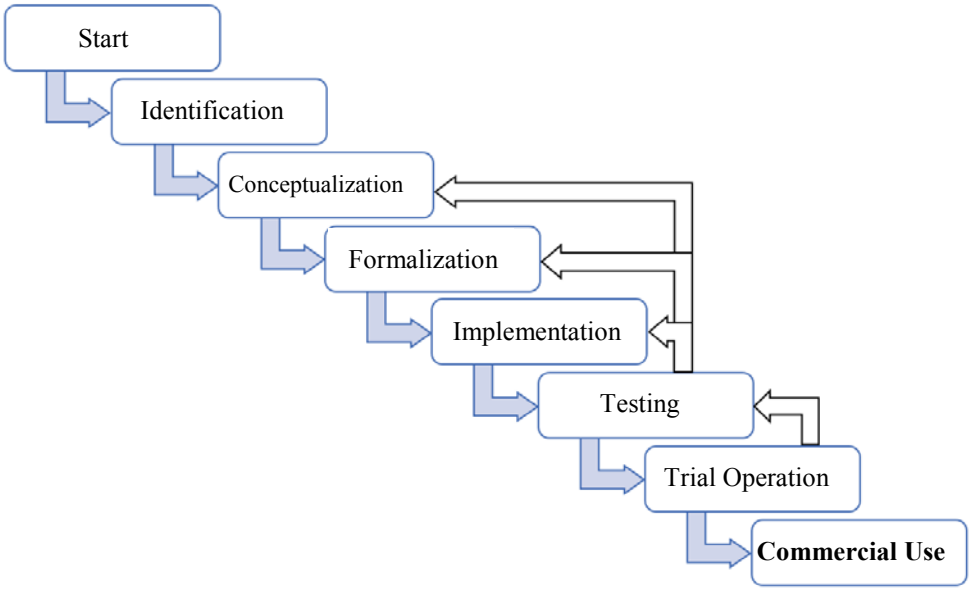

Fig. 1. Stages and content of tasks of expert system development

At the conceptualization stage, there is a delineation of the terms, relationships and management tools required to describe the methodology for the task implementation.

The content of the conceptualization stage includes the selection of concepts, relations and control mechanisms required to describe the solution to the problems under consideration. For example, the terms used to describe the current state of the organization can be defined by the standards: management for the sustainable success of the organization, strategy and policy, resource management, process management, monitoring, measurement, analysis and research, improvement, innovation and training.

At the formalization stage, structures are created for expressing knowledge, basic terms and relationships. The formal expression method in most cases is determined by the ES construction language. To construct a domain model, an approach based on the methodology of fuzzy sets was used [12–14].

The ES implementation and testing include writing a computer program, describing the rules that include knowledge, evaluating the given rules, and, ultimately, obtaining an assessment of the expert system as a whole.

To automate the solution to the self-assessment problem, a software package was created. Fig. 2 shows a block diagram of the software package created on the basis of the knowledge gained about the subject field [12–14].

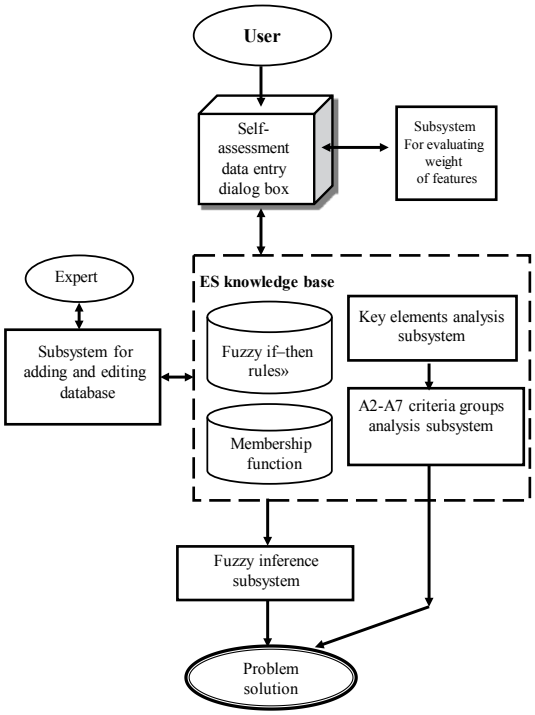

Fig. 2. Block diagram of an expert system

The ES implements the following functions:

— description of the sections of the QMS standards used in solving the problem of assessing the level of maturity of the organization;

— solving the problem of self-assessment based on 9 key criteria (according to GOST R ISO 9 004–2010);

— solution to the problem on the basis of 6 additional criteria [12-14];

— solving problems of determining the weight of the evaluation criteria[6];

— solving problems of formalizing fuzzy expert information;

— explanation of the results obtained;

— assistance to DM in the ES operation.

The set of ES components depends on the characteristic properties of the subject field and the primary requirements put forward during its development.

The mode of the system operation with knowledge plays a special role in the ES. In this mode, the user is provided with the following resources: loading the knowledge selected by the expert into the system; exclusion of the selected knowledge; changing knowledge; reading the knowledge base; conservation of knowledge.

The knowledge correction mode supports the addition of knowledge of the following types: assessment of the weight of factors, number of terms of linguistic variables, parameters of membership functions, production rules.

The ES operates in two modes: knowledge acquisition and problem solving.

The knowledge base is formed through the joint work of a knowledge engineer and a QMS expert.

The interaction of the user (DM) with the ES occurs in the mode of the problem solution. The implementation of the natural language interface with the user is realized through the dialog block for entering information.

The core component of all software products is a user interface designed for an unlimited number of users. Users (experts) can work in the system simultaneously, and their number is unlimited.

For the described ES, three types of dialogs are used: a menu-type dialog; a dialogue of the question-answer type; a dialogue based on screen forms.

Thus, the software package considered is a tool environment that enables the user to solve various problems of assessing the level of maturity of an organization in an interactive mode.

Research Results. The software product is designed as a cross-platform client-server application. All data are stored and processed on the web server; the user interacts with the web server using an Internet browser (all modern Internet browsers are supported: Mozilla Firefox, Google Chrome, Microsoft Edge, Opera, as well as their mobile versions). HTML and JS are used to implement the graphical user interface; the server logic is implemented in PHP. The user can work with the

[6] Nurutdinova IN, Shumskaya NN, Dimitrova LA. On the use of weight coefficients in the formation of expert information. In: Proc. 10th Anniversary Sci.-Pract. Conf. on State and prospects for the development of agricultural engineering. Rostov-on-Don, 2017. P. 332-334. (In Russ.)

client part of the application through a wide range of platforms (PCs, laptops, tablets, smartphones) and operating systems (Windows, MacOS X, Android, iOS).

After authorization (entering a username and password), the user goes to the start page of the application and gains access to the main menu of the system. If a survey is conducted with a specific expert for the first time, it is required to enter his attributes into the database in advance. This can be done by clicking on the link "New user registration" in the main menu of the system. In the event that the expert's data has already been entered into the system, the user can start conducting a survey both on key elements and on an extended list of questions (subsystem "detailed self-assessment, p. A2 – A7").

After the data entry completion, the user can immediately get the results of the assessment both on a simple scale and considering the previously entered weighting factors of the criteria through selecting the appropriate links in the main menu of the program. The result of solving the problem is presented in the text form, graphical, in the form of a RADAR diagram and an animated dashboard divided into sectors corresponding to each of the organizational maturity levels.

The application of this system, based on the knowledge of experienced specialists, will reduce time costs, expand the range of decisions made and improve their validity, and preserve the empirical knowledge gained under solving the self-assessment problem.

Fig. 3 shows the main menu of the system for the automated solution to the problem of assessing the level of maturity of the organization, and Fig. 4 – the user poll screen.

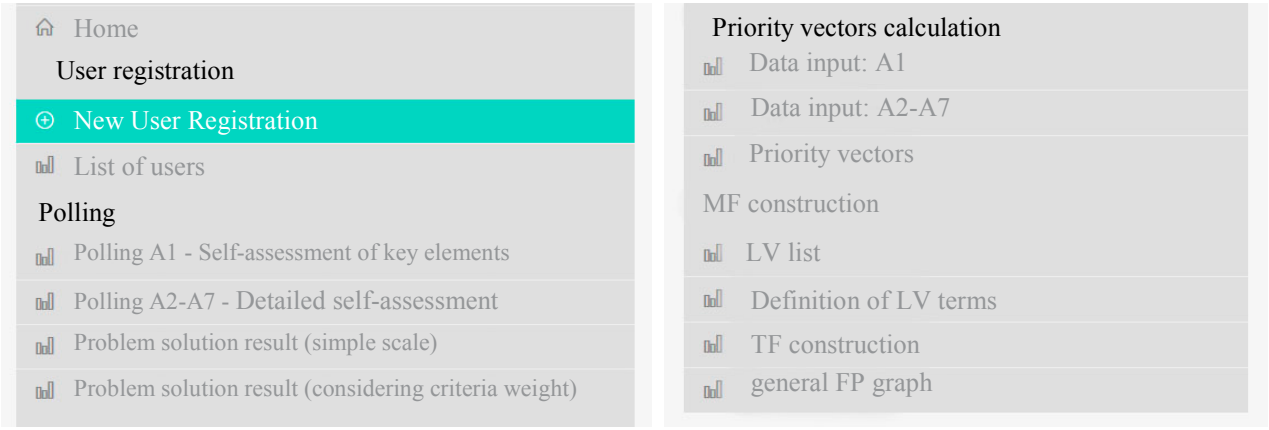

Fig. 3. Main menu of the software package

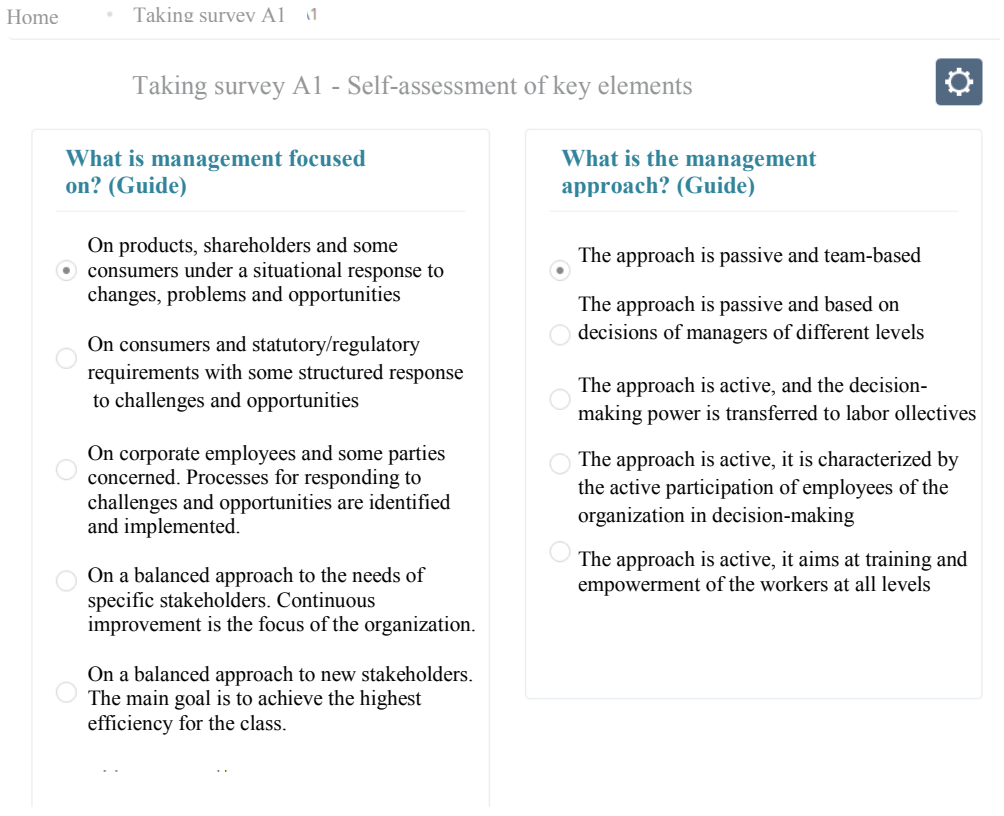

Fig. 4. User poll screen

The analysis of the survey results (based on the knowledge of the subject field entered by an expert) provides the DM with a solution to the problem (Fig. 5 and 6).

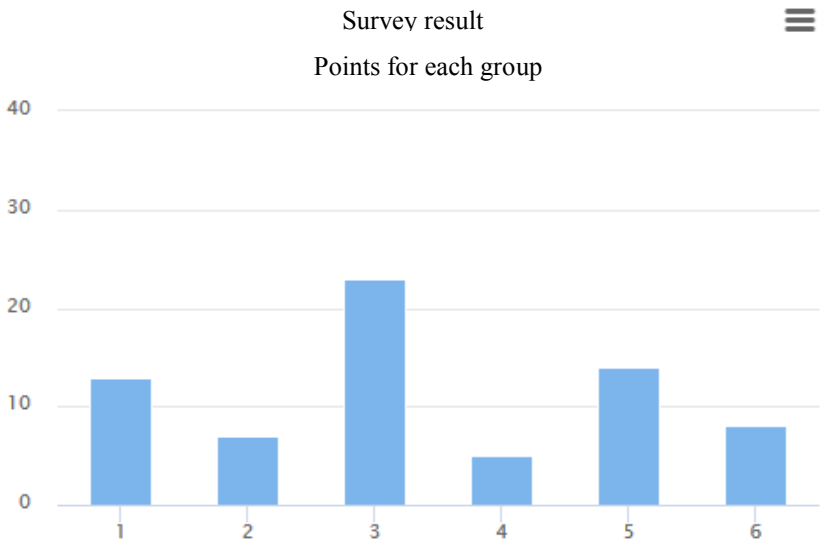

Fig. 5. General view of the user survey chart

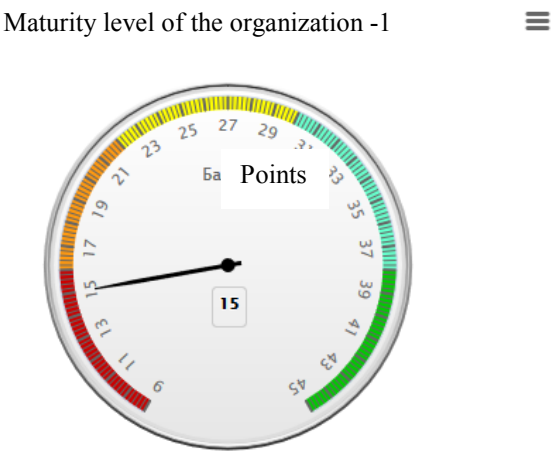

Fig. 6. Chart presentation of assessment results

The solution to the problem of assessing the level of maturity of an organization can be obtained taking into account the weight of both key indicators and the main groups of assessment criteria.

Discussion and Conclusions. The proposed software can be used to determine the level of maturity of an organization. The application of web technologies increases the usability and reduces the cost of software support. The software can be deployed in the existing network infrastructure of the customer; and the customer can use all the functionality through connecting to a remote server. The software is optimized for various screen resolutions, which allows it to be used not only in the central office, but also when analyzing the QMS of corporate customers. The traffic generated by the web application is optimized to work with mobile devices with slow Internet connections. The application of the program will significantly reduce the time for users to enter and process the expert information necessary to solve the problem, eliminate duplication of information.

An ES, which is a tool software environment, has been developed. Within the framework of ES operation, it is permissible to form the desired configurations of ES (knowledge input subsystems), which include various combinations of linguistic variables and all kinds of ways to construct membership functions. This ES is universal,

suitable for use in any business entity; it enables to classify the system by the level of maturity and to determine the potential for improvement.

The practical implementation of the developed algorithms is the creation of software for which certificates of intellectual property have been obtained (No. 2017660792 and No. 2017660791).

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Claimed contributorship

I. N. Nurutdinova: research objectives and tasks setting; the text revision; correction of the conclusions. L. A. Dimitrova: development of the software system structure; computational analysis; software design; text preparation; formulation of conclusions.

All authors have read and approved the final manuscript.